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Safety Education for Students of Microbiology*

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A. The Problem Area

Studies of microorganisms infections for man are conducted in many laboratories with little protection for the experimenters or for persons, such as dishwashers and clerical assistants, who are more or less remotely connected with the project. In fact, in many infectious disease laboratories, visitors, students, and other transients have free access to the laboratories. This has sometimes led to infection of such persons.

Although acquiring laboratory infections often has been viewed in the past as "part of the job," legal and moral considerations currently emphasize the need for protecting those associated directly and indirectly with the laboratory. For several reasons therefore, some laboratories are reluctant to work with certain organisms or to undertake microbiological experiments which, in themselves, are hazardous even though the organisms are of moderate infectivity under ordinary conditions, e.g., respiratory challenge of animals with *Bacillus anthracis*. Inasmuch as the respiratory route is often the normal means of infection, these are undesirable handicaps to the advancement of medical research.

Accurate estimates of the frequency of laboratory-acquired infections are difficult to obtain since only a relatively small percentage of the cases are recorded in the medical literature. Surveys conducted through questionnaires sent to laboratories have been useful but, again, there is little assurance of the completeness of such data, particularly in view of the fact that inapparent infections are seldom included. However, based on the information available, there is little doubt that occupational illness among medical and laboratory workers pose serious problems in many infectious disease laboratories. During a recent tour of 111 laboratories in 18 countries the author observed that 89 percent had problems connected with the handling of infectious disease agents.

But the problem does not end there. In an article discussing trends in microbiology, R. D. Reid (4) stated, "More and more contemporary scientists who are not microbiologists are turning to microbes as tools in working out answers to fundamental problems. . . . The use of microbes by other groups presents an added responsibility to bacteriologists. They must see to it that people have an acceptable working knowledge of basic microbiological techniques . . . This emphasizes the importance of a good teaching program in microbiology."

B. General Safety Considerations

In spite of all that has been written and said about the prevention of loss due to "accidents," it remains undisputed (as well as unsolved) that the single most important need in this area is that of convincing people that safety is a way of life, that it holds immediate and long

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range personal benefits and that it is an essential part of a well developed, orderly, full and enjoyable life. As Brody (1) has stated, "The psychology of safe behavior is no more and no less than the psychology of human behavior in general." Since the recognition of accident prevention as a worthwhile endeavor was realized early in the century, important gains have been made towards reducing needless loss of life and property due to accidents. Specifically, much has been done toward eliminating mechanical hazards or guarding machinery and apparatus which create unsafe conditions. Also, organized safety programs have become a routine part of our life and are usually evident in our schools, universities, factories, on our highways and, through various means, reach directly into our homes. Grimaldi (2) has stated, "Although safety programs are for the people, they are not of the people or by the people—unfortunately."

What then are the approaches that must be taken in order to "personalize" safety and make it a way of life? Education and training are useful approaches, but to be truly effective they must go beyond occasional five minute talks on safety by the supervisor. In fact, adequate education in safety must take into account a number of human traits as well as a good understanding of individual differences which may exist between people. People, after all, are the most important commodity with which we deal. And, according to the type of person being dealt with, one may want to select a particular approach as being of more potential benefit than some other. Ultimately however, for the safety of the person working in the infectious disease laboratory, the responsibility rests in some way with the teaching institution that provided his initial training in laboratory procedures. Endowing the would-be microbiologist with heuristic desires and technical knowledge is not enough. The student must be taught how to use the instruments and apparatus of the laboratory. He must, in the learning process, be made to understand the importance of the manipulations and impressed with the notion that a good scientist is also a safe scientist. The mental image of many past martyrs of science is likely to create problems in this area.

Insofar as laboratory infections are concerned, the safety problem in its simplest form is one of environmental control. The microbe must remain in its environment (test tube, flasks, etc.) and the microbiologist must assure himself that he is externalized from the organism environment. Although this appears simple and straight forward, its possible complexity can be illustrated by the fact that quantities of microbes capable of causing human infection are not readily detectable in the usual sense. The infecting dose may be odorless, tasteless and invisible to the eye.

C. Approaches to the Problem

Given that laboratory infections are a problem and that long-range improvement is best obtained by student safety education which parallels technical learning and development, one yet needs to consider how this may be done.

Encountered first may be the problem of convincing school authorities

(from the Dean to the instructors) of the need for training in infection prevention. All too often school authorities have long since solved all infectious problems simply by forbidding the use of infectious agents in the school's laboratories. This, of course, is "begging the question." Of course, it is true that not all microbiologists handle or need to handle infectious forms in their work. But telling the student who is taking a course in infectious diseases that if, later in his career, he is required to handle pathogens, his employer or someone else will give him the proper instructions is merely academic "buck-passing." Another evil is that complete or partial avoidance of pathogenic forms will foster dual techniques—one for use with "safe" microbes and another for use with pathogens. From the infection prevention point of view this is obviously undesirable since it increases the chance of using the wrong technique. Many outstanding microbiologists insist that all microorganisms should be handled as if they were deadly pathogens. Having one set of techniques produces less chance of confusion.

Once approval for the safety program is granted, the mechanics of the effort must be carefully considered. Instructors will have little trouble obtaining details on how to carry out individual procedures safely. Some difficulty may be experienced in obtaining funds for necessary safety equipment, but the larger obstacle will be the integration of laboratory safety programs into the instructional schedule and deciding what the objectives of the program should be.

D. The Laboratory Safety Program

The over all objective of the program, of course, should be to allow laboratory experiments and manipulations to be carried out safely without undue inconvenience. Students should be guided to develop the proper attitudes, sufficient skill and knowledge to prevent infectious or potentially infectious events. They should be taught the basic elements of accident prevention, paraphrased if necessary in microbiological terms. They should be taught the significance of accident reporting, which is doubly important in the infectious disease laboratory because of the interval (incubation period) between the accident and the possible onset of disease symptoms. In short, the future microbiologist should, upon graduation, be able to perform the skills required of his profession, do them safely and understand why the safety precautions are necessary.

In the laboratory, as well as in other areas, human failure is responsible for the majority of accidents. Therefore instruction in laboratory techniques should be given with the objective of constantly strengthening awareness and alertness in the handling of microorganisms. Instruction should be given with the realization that the student, later as a professional, may have to train his own laboratory technicians and, in effect, be his own safety director.

The following outline summarizes the essential features of school education in microbiological safety. It is probably desirable that most of this material be integrated with the regular laboratory and lecture work. It is certainly desirable that a personalized approach be used.

1. Safety in the infectious disease laboratory is achieved through:
 - a. Vaccination.
 - b. The use of correct techniques.
 - c. The use of safety equipment.
 - d. Properly designed laboratories.
 - e. The management techniques of reporting, analyzing, selecting and regulating.

The most important of these are the use of correct techniques and management techniques.

2. Laboratory infections:
 - a. Early observations reported in the literature.
 - b. Recent surveys and estimates of frequency.
 - c. Economic, moral and morale considerations.
3. Philosophy of infection prevention:
 - a. The accident syndrome.
 - b. Causal relationships.
 - c. The importance of reporting.
4. Common laboratory hazards:
 - a. Arising from use of equipment.
 - b. Arising from procedures and techniques.
 - c. Arising from human error.
5. Analysis of causal data:
 - a. Discovering trends through analysis of "no-loss" accidents.
 - b. Finding the "unknown" causes.
6. Corrective procedures:
 - a. Through training, regulating and supervising.
 - b. By designing safety into a new procedure or technique.
 - c. By modification of existing techniques.
 - d. By fixing of responsibility.
 - e. By safety testing to discover hazards.
7. Realistic laboratory safety regulations.

E. Discussion

That there is considerable interest in microbiological safety is indicated by the formation in October 1950 in the American Public Health Association of a Committee on Laboratory Infections and Accidents. This committee is still active. Of some influence also has been the recognition under workmen's compensation laws of certain occupational hazards, such as serum hepatitis and tuberculosis, among medical and laboratory personnel. Much in fact has been published on the incidence of tuberculosis among medical students. In England, D. D. Reid (3) recently published a study in which he concluded that the incidence of pulmonary tuberculosis among medical and laboratory workers was 2 to 9 times that which would be expected from a "normal" population. In the U. S., the well-known survey of Sulkin and Pike (5), published in 1951, gave an analysis of 1342 laboratory infections. Additional in-

terest in the problem has been expressed by the World Health Organization and others.

In general, the prime result of the above surveys and other publications on microbiological safety has been to illustrate that a problem exists and to indicate mechanical protective equipment and faulty techniques. Little has been done to institute realistic educational processes. For those who will agree that microbiologists and others who work with infectious microorganisms should be given every opportunity to protect themselves from acquiring occupational diseases, the question should be asked: Should not safety training in the hazards associated with handling highly virulent microbes be included in the undergraduates and graduate college curriculum? The modern educational system is expected to produce professional people who have the knowledge and the skills which will enable them to be effective in their chosen fields. If safe behavior is indeed a corollary of life and if important contributions to one's later attitudinal outlook are formed early in life, it is not realistic to wait until after the completion of professional training to institute education in safety.

F. Recommendations

In view of the infectious hazards encountered by medical and microbiological laboratory workers, and realizing that progress in the various fields where human pathogens are used present a constantly changing hazard scene, educators should consider the amelioration of safety educational programs within the teaching curriculum for students of microbiology, public health and medicine. In addition to imparting specific knowledge on technical means of controlling hazards, the objective of the training should be to influence attitudes and concepts toward loss prevention in laboratory operations to an extent that the student, at graduation, will think of safety as a natural and necessary part of laboratory life.

Before safety training can be successfully integrated into student courses it will become necessary to impart this knowledge to professors and instructors in these fields. The task promises to be formidable but nonetheless it should be made a part of future planning. Because of present emphasis on the teaching of science, many new and enlarged laboratories and teaching facilities are being constructed. Expanded courses in specialized areas of microbiology are being planned and larger teaching staffs are being sought. Now is certainly the time to incorporate safety education into the teaching of microbiology.

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